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(54) **Low temperature chemical vapor deposition of silicon dioxide films.**

(57) A method for low temperature chemical vapor deposition of an SiO<sub>2</sub> based film on a semiconductor structure using selected alkoxysilanes, in particular tetramethoxysilane, trimethoxysilane and triethoxysilane which decompose pyrolytically at lower temperatures than TEOS (tetraethoxysilanes). Ozone is introduced into the reaction chamber to increase deposition rates, lower reaction temperatures and provide a better quality SiO<sub>2</sub> film by generating a more complete oxidation. Ozone is also employed as a reactant for doping SiO<sub>2</sub> based films with oxides of phosphorus and boron.

**EP 0 212 691 A1**

# LOW TEMPERATURE CHEMICAL VAPOR DEPOSITION OF SILICON DIOXIDE FILMS

## Field of the invention

This invention relates to a method for depositing an SiO<sub>2</sub> based dielectric film on a semiconductor structure and in particular to a method for low temperature chemical vapor deposition of SiO<sub>2</sub> films using a selected alkoxysilane.

## BACKGROUND OF THE APPLICATION

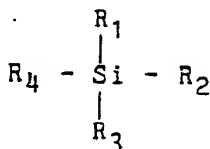
Tetraethoxysilane (TEOS) has been used extensively as the source material for the chemical vapor deposition (CVD) of an SiO<sub>2</sub> layer on a semiconductor wafer. U.S. Patent No. 3,934,060, issued to Burt et al. on January 20, 1976, describes one such prior art process.

In a typical prior art process nitrogen is used as the carrier gas which is passed over or bubbled through the TEOS which is held in a source container. The wafers to be covered with a deposited SiO<sub>2</sub> film are laid in a furnace boat in a furnace tube into which the TEOS vapor entrained in the carrier gas is introduced and the wafers are heated to a selected temperature at which the TEOS pyrolytically decomposes. The range of temperatures less than approximately 960°C at which TEOS pyrolytically decomposes is well known. As the temperature of the wafers is reduced the decomposition rate and the film deposition rate decrease until they appear to stop. As a practical matter the range of temperatures typically em-

ployed ranges between 650°C and 950°C. While the growth rate is lower for temperatures at the lower end of the range, these lower temperatures have the advantage of causing less thermal damage to the semiconductor circuit embedded in the underlying silicon wafer. These lower temperatures are also more compatible with metalization schemes using aluminum and its alloys.

U.S. Patent No. 3,934,060, referred to above, describes an improvement in the geometry and deposition technique of the typical prior art process, which results in a more uniform coverage of the wafers by the SiO<sub>2</sub> film.

It is also known that the growth rate of the SiO<sub>2</sub> layer can be enhanced by using oxygen as a carrier gas (See U.S. Patent No. 3,614,584, issued to Inoue on October 19, 1971). The Inoue patent also describes a method for depositing TEOS using tetraethoxysilane as a source together with trisopropyl titanate in order to deposit a composite insulating layer of TiO<sub>2</sub>-SiO<sub>2</sub> where the TiO<sub>2</sub> constitutes less than 0.02% by weight of the layer. Inoue employs the temperature range of 300°C to 500°C for the above process. Other methods using plasma deposition techniques are known for depositing an SiO<sub>2</sub> based film on a video disk. For example, U.S. Patent No. 4,282,268, issued August 4, 1981 to Priestley et al., which is incorporated herein by reference, describes a method for forming an SiO<sub>2</sub> layer on a video disk by introducing into an evacuated chamber a dielectric precursor having the formula



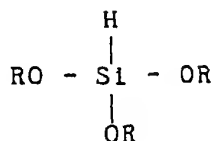
where R<sub>1</sub> is selected from the group H and -CH<sub>3</sub>, R<sub>2</sub> and R<sub>3</sub> are independently selected from the group consisting of H, -CH<sub>3</sub>, -OCH<sub>3</sub>, and -OC<sub>2</sub>H<sub>5</sub>, and R<sub>4</sub> is selected from the group consisting of -OCH<sub>3</sub> and -OC<sub>2</sub>H<sub>5</sub>. The SiO<sub>2</sub> layer is deposited onto the disk using a glow discharge. This method has proven unsuitable for depositing an SiO<sub>2</sub> based film on a semiconductor wafer because the deposited film has a poor dielectric quality, low density and is

highly particulate, and because the deposited film has poor step coverage.

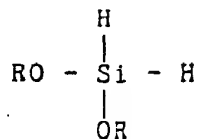
## SUMMARY OF THE INVENTION

In contrast to the prior art use of TEOS for the pyrolytic decomposition of SiO<sub>2</sub> based films on semiconductor structures the present invention utilizes other selected alkoxysilanes which permit the reactions to proceed at lower temperatures and at higher deposition rates. In one embodiment, the

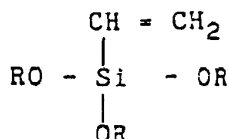
semiconductor structure is heated to a selected temperature less than or equal to 900°C and an alkoxysilane selected from the group consisting of tetramethoxysilane, a trialkoxysilane having the formula



where R is a methyl, ethyl or propyl group, a dialkoxysilane having the formula



where R is a methyl, ethyl, or propyl group or a vinyltrialkoxysilane having the formula



where R is a methyl or ethyl group. Oxygen and/or nitrogen are used as a carrier gas with oxygen being preferred. When the wafer temperature is reduced to a range between 550°C and 650°C the alkoxysilane may be selected to be tetramethoxysilane, triethoxysilane or trimethoxysilane. When the reaction temperature is selected to be between 350°C and 550°C the alkoxysilane selected may be tetramethoxysilane or trimethoxysilane.

It has also been discovered that when ozone is introduced into the reaction chamber along with nitrogen or oxygen, with the concentration of ozone preferably being less than or equal to 10% by weight, the reaction rate is increased by nearly an order of magnitude for alkoxsilanes. Alternatively, this introduction of ozone permits the reaction to proceed at lower temperatures for a given SiO<sub>2</sub> deposition rate. For example, using a trialkoxysilan (including a vinylalkoxysilane) or a dialkoxysilane the wafer temperature may be selected to be in the range of 350°C to 500°C. A temperature

in this range has distinct advantages in semiconductor processing since it is compatible with the wafer metalization and there is little or no thermal damage to the electrical properties of the circuits embedded in the silicon wafer. It has also been discovered that the use of ozone in the reaction chamber permits the doping of the SiO<sub>2</sub> film with oxides of phosphorous and boron at temperatures between 350°C and 900°C. The use of ozone in this connection provides an important advantage over the prior art since it greatly reduces the temperatures at which the doping oxides are formed compared to those required when oxygen alone is used as a carrier gas.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a reactor suitable for employing the methods of this invention.

Fig. 2 shows a reactor similar to Fig. 1 including a second bubble chamber for use in depositing a doped SiO<sub>2</sub> film.

#### Detailed Description

Fig. 1 shows a cross-sectional schematic diagram of a microreactor 10 for employing the methods of the present invention for chemical vapor deposition of an SiO<sub>2</sub>-based dielectric film on a semiconductor structure, for example a silicon wafer. Microreactor 10 is described in a copending application of Imad Mahawill entitled "Microreactor" filed with the US Patent and Trademark Office on the same date as the present application. Microreactor 10 includes housing 1 surrounding reactor chamber 2. Housing 1 is made of stainless steel or other inert material which does not react with the gases introduced into chamber 2. Heater plate 3, typically a block made of stainless steel, is held in position in chamber 2 by support rod 5 attached to housing 1. Silicon wafer 4, upon which the SiO<sub>2</sub>-based film is to be deposited, is placed on heater plate 3. The temperature of plate 3 is regulated by temperature controller 6 which is connected to via thermocouple 7 to a cartridge heater embedded in heater plate 3.

Silicon wafer 4 rests upon heater plate 3 and is heated thereby to a selected temperature as determined by temperature controller 6. Reactor 10 can be operated in the isothermal or cold-wall modes for a range of temperatures from room temperature up to 900°C. Exhaust chamber 14 is connected to a vacuum pump (not shown) so that microreactor 10 can be operated at reduced pressures, if de-

sired. In the methods of depositing SiO<sub>2</sub>-based films described herein, reactor 10 was operated at pressures ranging from atmospheric pressure down to 0.5 torr.

5 An alkoxysilane 9 is introduced into bubble chamber 8 at atmospheric pressure and room temperature (at room temperature, alkoxysilanes are generally in liquid form). A carrier gas, such as nitrogen or oxygen is introduced via gas line L<sub>1</sub>.  
10 The flow rate of the carrier gas into alkoxysilane 9 in bubble chamber 8 is regulated by control valve V<sub>1</sub>. The carrier gas, together with alkoxysilane vapor, flows from bubble chamber 8 via gas line L<sub>2</sub> to the elongated portion 11 of reactor chamber 2 as shown in Fig. 1. The flow rate through line L<sub>2</sub> is controlled by valve V<sub>2</sub>. A second selected mixture of one or more gases, for example oxygen, nitrogen, or ozone, may also be introduced into the elongated portion 11 of chamber 2 via line L<sub>3</sub> which is regulated by flow rate control valve V<sub>3</sub>.

20 The above chemical vapor deposition reactor was used in order to study the deposition rates of SiO<sub>2</sub>-based films for selected alkoxysilanes not previously used for the chemical vapor deposition of SiO<sub>2</sub>-based films on semiconductor wafers. Wafer 4 was maintained at various selected temperatures for selected carrier gases introduced via line L<sub>1</sub> and for selected gases introduced via line L<sub>3</sub>. The deposition rate for the SiO<sub>2</sub>-based film using prior art alkoxysilane tetraethoxysilane Si(OC<sub>2</sub>H<sub>5</sub>)<sub>4</sub> (TEOS) was used as a control process. Absolute deposition rates were not measured for the alkoxysilanes tested. However, relative rates were determined by visual inspection of the deposited SiO<sub>2</sub> film. The reactor was operated in both the cold wall mode and the hot wall mode.

#### CONTROL PROCESS 1

Alkoxysilane:	tetraethoxysilane (TEOS) Si(OC <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> , electronic grade 99.9% pure; molecular weight, 208.3 g/mole; boiling point 169°C
Carrier gas via line L <sub>1</sub> :	Nitrogen
Gas via line L <sub>3</sub> :	None (line L <sub>3</sub> off)
Flow rate via line L <sub>1</sub> :	20-100 sccm (20, 50, 100) sccm
Flow rate via line L <sub>3</sub> :	0

Wafer temperature: 650°C - 900°C (650°, 700°, 750°, 900°) ±20°C

Reaction time: 15-30 minutes (15, 30) minutes

Pressure: 1 atmosphere to 0.5 torr  
(1 atmosphere, (10, 5, 0.5) torr)

Control process 1 was carried out for the specific choices of flow rates, temperatures and pressures indicated in parentheses.

#### Example 1

Same as control process 1 except tetramethoxysilane,  $\text{Si}(\text{OCH}_3)_4$ , having a molecular weight of 152.2 g/mole and a boiling point of 121-122°C was used in place of tetraethoxysilane.

#### Example 2

Same as control process 1 except triethoxysilane  $\text{H-Si}(\text{OC}_2\text{H}_5)_3$ , having a molecular weight of 164.3 g/mole and a boiling point of 131.1°C was used in place of tetraethoxysilane.

#### Example 3

Same as control process 1 except that trimethoxysilane,  $\text{H-Si}(\text{OCH}_3)_3$ , 95% pure, having a molecular weight of 122.2 and a boiling point of 86-87°C was used in place of tetramethoxysilane.

Control process 1 and examples 1 through 3 all yielded  $\text{SiO}_2$  films with the following relative deposition rates,  $r$ :  $r(\text{tetraethoxysilane}) < r(\text{triethoxysilane}) < r(\text{tetramethoxysilane}) < r(\text{trimethoxysilane})$ .

#### CONTROL PROCESS 2

Same as control process 1, except that 99.999% pure  $\text{O}_2$  was used as the carrier gas via line 1 in place of nitrogen. Again control process 2 was carried out for the specific choices of flow rates, temperatures and pressures within the ranges stated as indicated by the values in parentheses.

#### 10 Example 4

Same as control process 2, except that tetramethoxysilane was used in place of tetraethoxysilane.

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#### Example 5

Same as control process 2, except that triethoxysilane was used in place of tetraethoxysilane.

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#### Example 6

Same as control process 2, except that trimethoxysilane was used in place of tetraethoxysilane.

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Control process 2 and examples 4 through 6 all yield  $\text{SiO}_2$  films with the following relative deposition rates:  $r(\text{tetraethoxysilane}) < r(\text{triethoxysilane}) < r(\text{tetramethoxysilane}) < r(\text{trimethoxysilane})$ .

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An examination of the above processes and examples showed that corresponding reaction rates were increased when oxygen was used as a carrier gas in place of nitrogen.

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#### CONTROL PROCESS 3

Same as control process 2, except that the wafer temperature was 550-650°C. (550°C, 600°C, 650°C) ±20°C were the actual wafer temperatures employed.

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Examples 7, 8 and 9 are the same as examples 4, 5 and 6, except that the wafer temperature was a selected temperature in the range 550-650°C (550°C, 600°C, 650°C) ±20°C were the wafer temperatures selected. The deposition rates in this lower temperature range were ordered in the same way as given for examples 4, 5 and 6; however, it was noted that very little  $\text{SiO}_2$  film was deposited for TEOS (tetraethoxy silane).

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## CONTROL PROCESS 4

Same as control process 2, except that reaction temperature was reduced to a selected temperature in the range 450-550°C. Examples 10, 11 and 12 are the same as examples 4, 5 and 6, except that the wafer temperature was a selected temperature in the range 450° to 550°C. The temperatures selected were 450°C, 500°C, and 550°C ±20°C. At these lower temperatures, no SiO<sub>2</sub> film was formed using the control process 4 or the example process number 11. An SiO<sub>2</sub> film was formed in examples 10 and 12 with the SiO<sub>2</sub> deposition rate  $r(\text{tetramethoxysilane}) < r(\text{trimethoxysilane})$ .

## CONTROL PROCESS 5

Same as control process 2 except that the wafer temperature was a selected temperature in the range 350-450°C. The selected temperatures were 350°C, 400°C and 450°C ±20°C.

Examples 13, 14, and 15 are the same as examples 4, 5, and 6 except that the wafer temperature was in the range 350-450°C. At these reduced temperatures, no SiO<sub>2</sub> film was formed using the method of control process 5 or example 14. A very thin film formed using the process of example 13. A thicker film was formed using the process of example 15, i.e.,  $r(\text{tetramethoxysilane}) < r(\text{trimethoxysilane})$ .

The above examples for semiconductor applications demonstrate that an SiO<sub>2</sub> film of good dielectric quality can be deposited from decomposition of various alkoxysilanes other than TEOS.

The use of tetramethoxysilane, triethoxysilane and trimethoxysilane permits lower wafer temperatures (≤650°C) than prior art TEOS which is deposited at temperatures between 650°C and 900°C.

In particular, a good quality SiO<sub>2</sub> based film is deposited using tetramethoxysilane or trimethoxysilane at wafer temperature as low as 350-550°, good quality SiO<sub>2</sub> based film is deposited using tetramethoxysilane, trimethoxysilane, and triethoxysilane at wafer temperatures of 550°C to 650°C. Moreover, in the temperature range 550° to 650°C, the deposition rate of the SiO<sub>2</sub> based film was greater using tetramethoxysilane, trimethoxysilane and triethoxysilane than the deposition rate using TEOS.

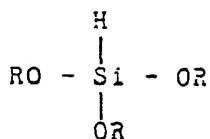
Depositing an SiO<sub>2</sub> based film on an IC silicon wafer using these lower reaction temperatures has an important advantage over the higher temperature reaction required when using TEOS since the electrical properties of the integrated circuit wafer are less affected by lower temperature processing. For example, lower temperature processing causes less diffusion of dopants in the underlying integrated circuit and is more compatible with aluminum metalization.

The use of the methoxysilanes described above has the added advantage that they reduce the amount of residual carbon in the deposited SiO<sub>2</sub> based film, which enhances the dielectric quality of the film.

In Examples 1 through 15, above, the alkoxysilanes used were tetramethoxysilane, triethoxysilane or triethoxysilane.

However, in general the following alkoxysilanes may be employed with the method of this invention:

(1) a trialkoxysilane having the formula



where R = a methyl (CH<sub>3</sub>),

ethyl (C<sub>2</sub>H<sub>5</sub>), or

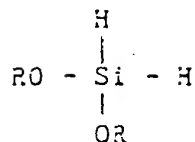
propyl (C<sub>3</sub>H<sub>7</sub>) group

(2) a dialkoxysilane having the formula

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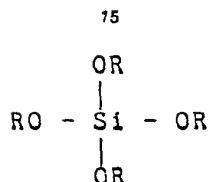
where R = a methyl (CH<sub>3</sub>),

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(3) a tetramethoxysilane

ethyl (C<sub>2</sub>H<sub>5</sub>), or

propyl (C<sub>3</sub>H<sub>7</sub>) group

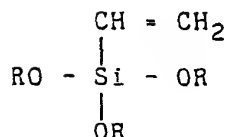


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where R = methyl (CH<sub>3</sub>), or

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(4) a vinyltrialkoxysilane having the formula



where R = a methyl (CH<sub>3</sub>), or

ethyl (C<sub>2</sub>H<sub>5</sub>) group

It has also been discovered that important advantages can be obtained using ozone as a reactor gas, in particular:

(1) for selected alkoxysilanes, such as trialkoxysilanes, vinyltrialkoxysilanes, and dialkoxysilanes, the wafer temperature may be reduced to the range of 300°-500°C, a temperature which does not adversely affect the properties of active and passive devices formed in and on the wafer surface;

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(2) for the temperature range 300°-900°C a better quality SiO<sub>2</sub> dielectric film having lower residual carbon is obtained due to a more complete oxidation reaction;

(3) the deposition rate of the SiO<sub>2</sub> dielectric film is increased; and

(4) doping of the SiO<sub>2</sub> film with both phosphorous and boron oxides is readily achievable.

Example 16, below, provides one example of the use of ozone in the chemical vapor deposition of SiO<sub>2</sub> based films.

In example 16, where ozone is employed as a reactant gas, one may use any alkoxysilane including tetraethoxysilane (TEOS).

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## Example 16

Alkoxysilane:	tetraethoxysilane, tetramethoxysilane, triethoxysilane, or trimethoxysilane
Carrier gas via line L <sub>1</sub> :	O <sub>2</sub> or Nitrogen
Reactant gas via line L <sub>3</sub> :	O <sub>2</sub> and less than 10% ozone by weight
Flow rate for carrier gas via line L <sub>1</sub> :	20-100 sccm (20, 50, 100) sccm
Flow rate for gas via line L <sub>3</sub> :	20-200 sccm (20, 50, 100, 200) sccm
Wafer temperature:	300 - 900°C (300°C, 350°C, 400°C, 500°C, 600°C, 700°C, 800°C, 900°C) ±20°C
Pressure:-	1 atmosphere to 0.5 torr (1 atmosphere, (10, 5, 0.5) torr)

(The values of the parameters in parenthesis indicate the values tested)

Example 16 may be modified by using a mixture of O<sub>2</sub> and nitrogen for the carrier gas via line L<sub>1</sub>, or by using a mixture of O<sub>2</sub>, nitrogen and less than 10% ozone by weight for the reactant gas via line L<sub>3</sub>.

In another embodiment of the invention example 16 was modified by using a mixture of O<sub>2</sub> and less than 10% ozone for the carrier gas via line L<sub>1</sub>, with line L<sub>3</sub> turned off, but it is preferable to introduce ozone via line L<sub>3</sub>.

<sup>30</sup> An ozone generator (not shown) containing a standard electrodeless discharge tube and capable of producing a concentration of 10% ozone by weight or less from a feed stream of pure oxygen is attached to line L<sub>3</sub>.

<sup>35</sup> Figure 2 shows a reactor suitable for producing a doped SiO<sub>2</sub> film. Figure 2 is similar to Figure 1 except that a second bubble chamber 15 is provided which contains a dopant source, for example trimethylphosphite or trimethylborate. A carrier gas such as O<sub>2</sub> or N<sub>2</sub> is introduced into the dopant source via line L<sub>4</sub> which is controlled by valve V<sub>4</sub>.  
<sup>40</sup> The doped gas passes via control valve V<sub>5</sub> and line L<sub>5</sub> into mixing chamber 11.

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## Example 17 (not tested)

Alkoxysilane:	any alkoxysilane
Carrier gas via Line L <sub>1</sub> :	O <sub>2</sub> or Nitrogen
Reactant gas via Line L <sub>3</sub> :	O <sub>2</sub> and less than 10% ozone by weight
Carrier gas via line L <sub>4</sub> :	O <sub>2</sub> or Nitrogen
Flow rate via line L <sub>1</sub> :	20 - 100 sccm
Flow rate via line L <sub>3</sub> :	20 - 200 sccm
Flow rate via line L <sub>4</sub> :	20 - 100 sccm
Wafer temperature:	300° - 900°C
Pressure:	1 atmosphere to 0.5 torr
Dopant:	trimethylphosphite P(OCH <sub>3</sub> ) <sub>3</sub>

The advantage of using ozone in the gas stream is that ozone readily oxidizes both phosphorous and boron hydrides and alkoxides which are used as dopant sources for doping SiO<sub>2</sub> films. Moreover, oxidation takes place at substantially lower temperatures than when pure O<sub>2</sub> is used as the carrier gas. Thus, while the temperature range shown in example 17 is 300-900°C, the preferred temperature range is lower for selected alkoxysilanes. For example, for a trialkoxysilane the preferred temperature range is 300-500°C, which does not damage the underlying semiconductor structure.

The above examples are meant to be exemplary and not limiting and in view of the above disclosure many modifications will be obvious to one of ordinary skill in the art without departing from the scope of the invention.

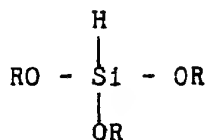
In particular, the precise configuration of the deposition reactor is not critical to using the methods of this invention and one of ordinary skill in the art will be able to employ other suitable reactors in view of the disclosures made herein.

## Claims

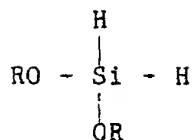
1. A method of forming a SiO<sub>2</sub> based layer by chemical vapor deposition on a semiconductor structure in a reactor chamber characterized by the following steps:

heating said semiconductor structure to a selected temperature less than or equal to 900°C; and

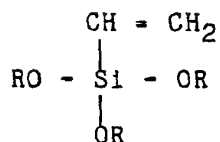
introducing a gas vapor reactant, said reactant being selected from the group consisting of tetramethoxysilane, a trialkoxysilane having the formula



where R is methyl, ethyl, or propyl group, a dialkoxysilane have the formula



where R is methyl, ethyl, or propyl group, or a vinyltrialkoxysilane, having the formula 10



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where R is methyl or ethyl group,

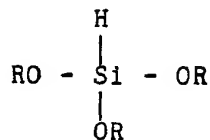
so that said SiO<sub>2</sub> based layer is formed by the pyrolytic decomposition of said reactant.

2. A method of forming a SiO<sub>2</sub> layer by chemical vapor deposition on a semiconductor structure in a reactor chamber characterized by the following steps:

heating said semiconductor structure to a selected temperature less than or equal to 900°C; and

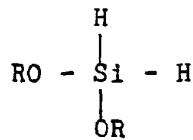
introducing a first gas vapor reactant, said first gas vapor reactant being selected from the group consisting of tetramethoxysilane, a trialkoxysilane having the formula

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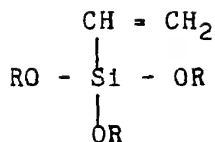
where R is methyl, ethyl, or propyl group, a dialkoxysilane have the formula

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where R is methyl, ethyl, or propyl group, or a vinyltrialkoxysilane, having the formula 50

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where R is methyl, or ethyl group, and a second oxidizing reactant so that an SiO<sub>2</sub> based layer is formed by the thermal reaction of said first gas vapor reactant and said second oxidizing reactant.

3. The method of Claim 1 or Claim 2 further including setting the pressure in said reactor chamber to a pressure between one atmosphere and 0.5 torr.

4. The method of Claim 3 wherein said selected temperature is between 350°C and 650°C.

5. The method of Claim 3 wherein said first selected reactant is tetramethoxysilane, triethoxysilane or trimethoxysilane and said second oxidizing reactant is oxygen and said selected temperature is between 550°C and 650°C.

6. The method of Claim 3 wherein said first selected reactant is tetramethoxysilane or trimethoxysilane and said oxidizing reactant is oxygen and said selected temperature is between 350°C and 550°C.

7. The method of forming a SiO<sub>2</sub> based layer by chemical vapor decomposition on a semiconductor structure in a reactor chamber characterized

10 by the following steps:

heating said semiconductor structure to a selected temperature less than or equal to 900°C; and

15 introducing a gas vapor alkoxysilane and a reactant gas containing ozone so that said SiO<sub>2</sub> based layer is formed at least in part by the thermal reaction of said alkoxysilane and said ozone.

8. The method of Claim 7 wherein said selected temperature is between 300°C and 500°C and the proportion of ozone in said reactant gas is less than 10 percent by weight.

9. The method of Claim 8 wherein said reactant gas comprises oxygen.

20 10. The method of Claim 7 further including the step of introducing a gaseous reactant containing boron or phosphorus into said reactor chamber.

11. The method of Claim 10 wherein said selected temperature is between 300°C and 500°C.

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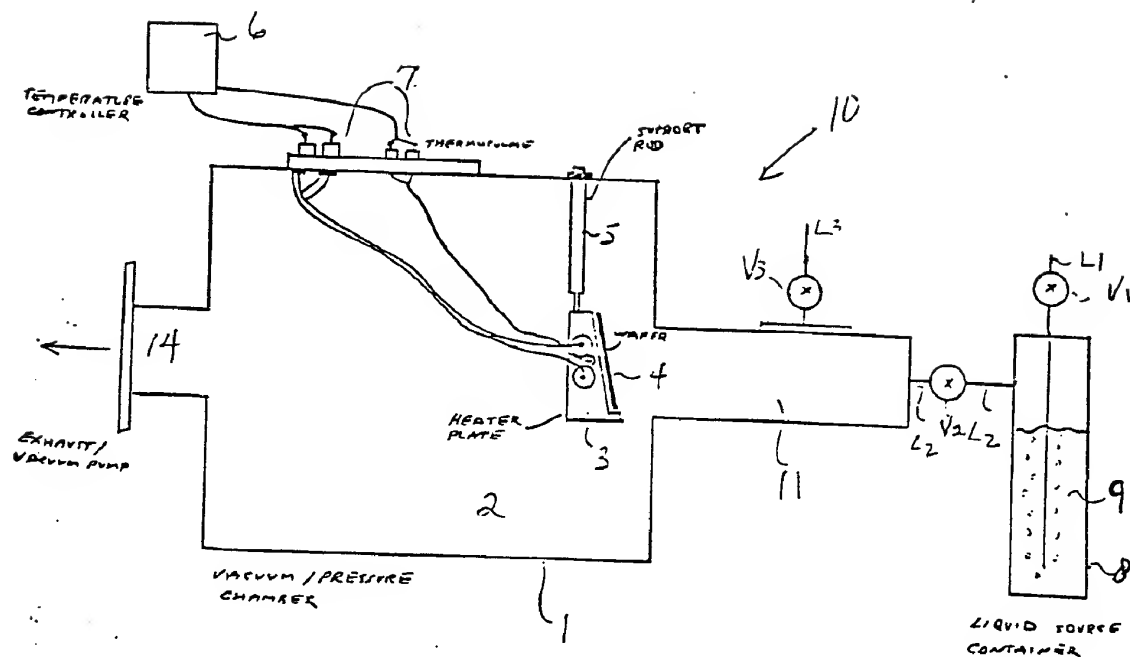
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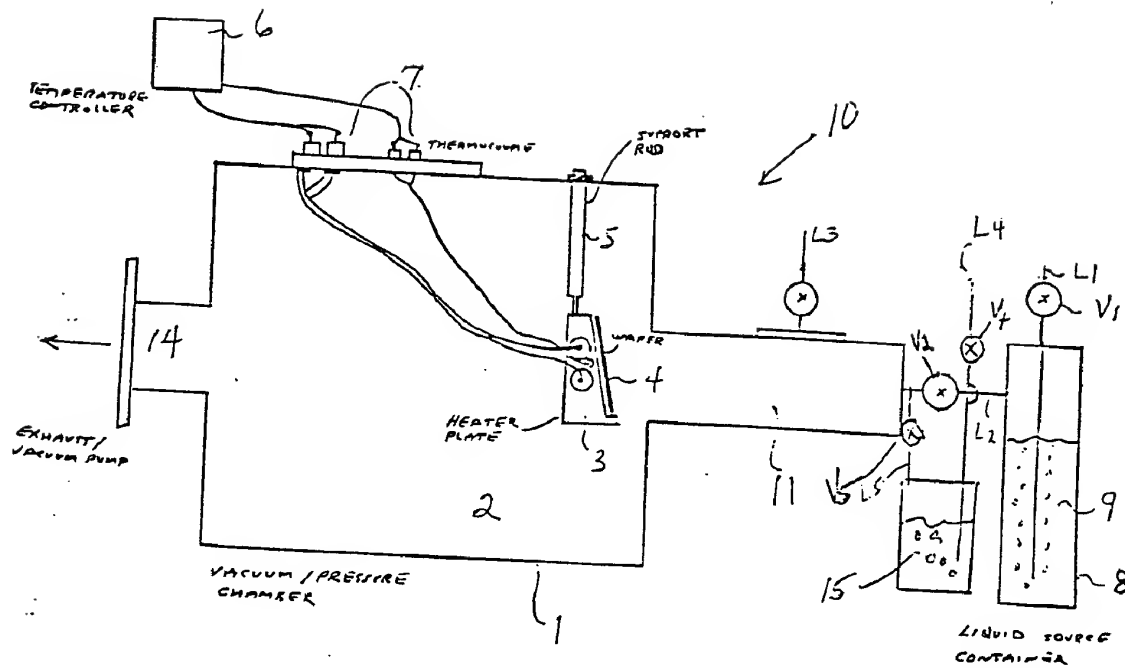
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CONNECT VALVE 1 TO INERT GAS ( $N_2$ ), OXYGEN, REACTANT GAS (CONTROL)  
 CONNECT VALVE 2 TO " " " " (CONTROL).

Fig. 1  
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CONNECT VALVE 1 TO INERT GAS (N<sub>2</sub>), OXYGEN, REACTANT GAS (CONTROL)  
 CONNECT VALVE 2 TO " " " " (CONTROL).

Fig. 2

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European Patent  
Office

# EUROPEAN SEARCH REPORT

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 86201002.2
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
D, X	US - A - 4 282 268 (E.B. PRIESTLEY et al.) * Abstract; claims *	1, 5	C 23 C 16/40 H 01 L 21/316
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X	US - A - 4 099 990 (D.E. BROWN et al.) * Column 2; claims *	1, 2, 4-6, 9	
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A	EP - A1 - 0 141 496 (MORTON THIO-KOL, INC.) * Claims *	1, 3, 4, 9, 10	
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A	DE - A1 - 2 536 013 (ROBERT BOSCH GMBH) * Page 4; page 6, lines 20-25 *	1	
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A	DE - B2 - 2 148 120 (INTERNATIONAL BUSINESS MACHINES CORP.) * Claims *	1, 4, 5, 10	C 23 C H 01 L
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A	GB - A - 2 132 637 (LFE CORPORATION) * Claims *	1, 10, 11	
	--		
A	GB - A - 1 550 532 (SUMITOMO CHEMICAL COMPANY LIMITED) * Claim 1 *	1	
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The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 15-10-1986	Examiner SLAMA
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	